Trade-offs associated with adapting to novel host plants

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Introduction

Changes in management strategies may be required when pest insects adapt to novel crops. We use the seed beetle *Callosobruchus maculatus* as a model system to study the evolution of insect diets. A primary goal has been to understand how beetles adapt to a very poor host (lentil), and the possible trade-offs involved in this process. The trade-off hypothesis predicts that adapting to a novel host simultaneously reduces performance on the ancestral host.

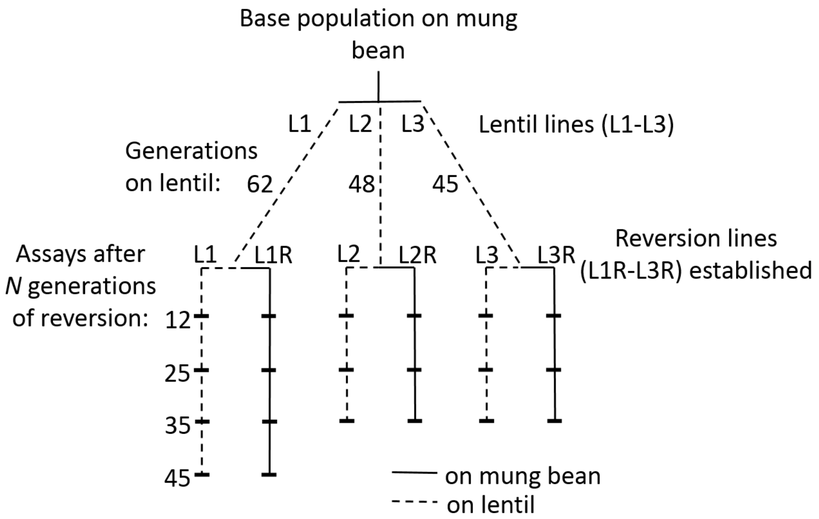

Fig. 1. Experimental design: lentil lines (L1-L3) were established independently from a mung-bean line. After 45-62 generations, sublines (L1R- L3R) were reverted back to mung bean.

Selection Experiment

When replicate beetle lines were originally switched from their ancestral host (mung bean) to lentil, survival on lentil rapidly increased from 1-2% to >90% within 30 generations (Fig. 2), and the tendency of females to lay eggs on lentil (not shown) increased two-to three-fold.

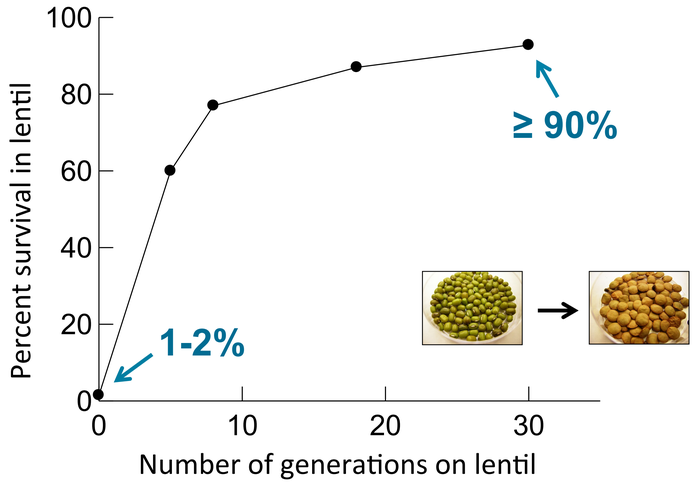

Fig. 2. Survival on lentil rose from 1-2% to >90% in 30 generations.

Reversion Experiment

To test for trade-offs, we performed a reversion experiment in which sublines were maintained on lentil or reverted back to mung bean. Reversion experiments can help determine whether genotypes that allow insects to perform well on a novel host become sub-optimal when selection is relaxed. If trade-offs are important, the reversion lines should eventually show a loss of adaptation on lentil. After 12-55 generations, we compared reverted and non-reverted lines for both larval performance (Fig. 3) as well as host acceptance (Fig. 4) on lentil.

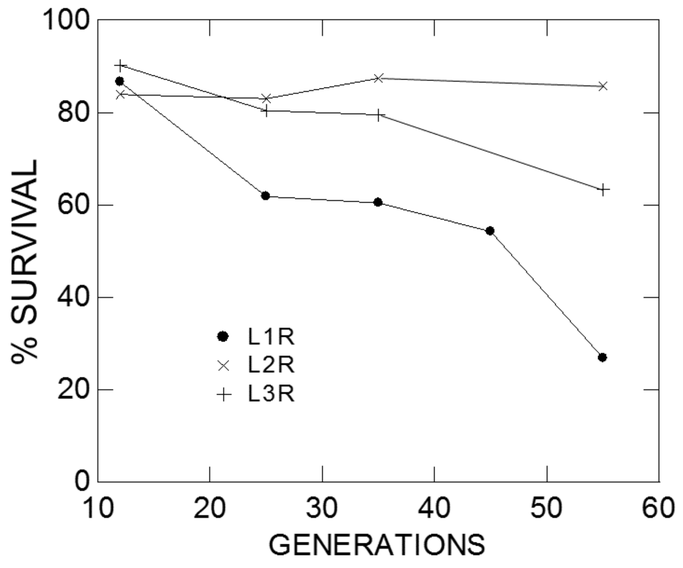

Fig. 3. Survival from egg hatch to adult emergence in three sub-lines that were reverted to mung beans for 12-55 generations.

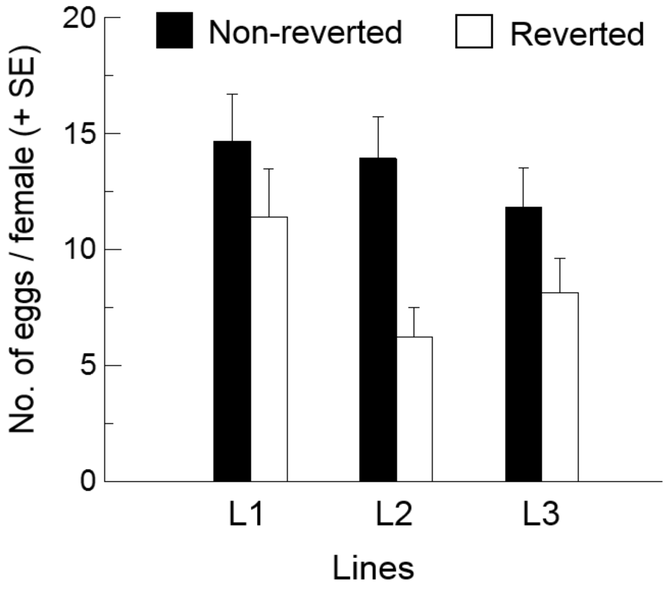

Fig. 4. Acceptance of lentil by females from non-reverted lines and reverted lines after 40 generations of reversion.

Table 1. Survival to adult emergence, egg-to-adult development time, and adult mass at emergence in lentil for a line that had been reverted back to the ancestral host for 45 generations

		Larval Host	
Trait	Sex	Nonreverted	Reverted
Survival (%)		92.2	54.2
Development time (days)	Females	34.1 ± 0.1	39.8 ± 0.6
	Males	33.4 ± 0.2	39.2 ± 0.5
Adult mass (mg)	Females	5.32 ± 0.05	4.78 ± 0.09
	Males	3.91 ± 0.04	3.69 ± 0.06

Phenotypic Assays

After 55 generations of reversion, larval survival dropped dramatically in the two of the three reversion lines (Fig. 3). Loss of adaptation was also observed for development time and body mass in all lines. For example, development time in L1R was five days slower than in L1, and adult mass was 6-10% lower (Table 1). Additionally, the host acceptance results show that, after 40 generations, females from the reverted lines laid fewer eggs on lentil over their lifetimes than females from the non-reverted lines (Fig. 4). The difference in host acceptance between females from reverted and non-reverted lines was somewhat inconsistent among assays, however, and we are now examining host acceptance after 62 generations of reversion.

Genomic Analyses

Partial genome sequences from the reversion lines, the non-reversion lines, and the original mung-bean line indicated that adaptation to lentil appeared to be mediated by standing genetic variation at multiple loci. Some alleles that were favored on lentil were selected against during reversion to mung bean, which is consistent with the genetic trade-off hypothesis. Genetic evidence also suggests that the genomic composition of the reverted lines converged toward that of the ancestral mung bean line. Because effective population sizes were relatively large, loss of adaptation to lentil in the reversion lines cannot be explained by genetic drift. Future research will focus on sequencing newly established lentil lines to observe generation-to-generation changes in allele frequencies during the initial stages of adaptation.

Acknowledgements

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